Canadian Grain Commission
Commission canadienne des grains

GRAIN RESEARCH LABORATORY

ANNUAL REPORT 1991-92

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GRAIN RESEARCH LABORATORY
65th ANNUAL REPORT : 1991-92

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GRAIN RESEARCH LABORATORY • 1991-92 REPORT

July 17, 1992

Canadian Grain Commission
Winnipeg, Manitoba

Commissioners:

I am pleased to submit the following report reviewing the activities of the Grain Research Laboratory for the period April 1, 1991 to March 31, 1992.

Respectfully,

K.H. Tipples.

K.H. TIPPLES
Director

INTRODUCTION

The Grain Research Laboratory (GRL) division of the Canadian Grain Commission has developed and maintained an international reputation for expertise in grain quality analysis since 1913. Maintaining this reputation is even more important today as buyers of Canadian grain become increasingly sophisticated with respect to quality aspects and want to feel assured that they are getting the best possible quality and value in their purchases.

The GRL attempts to relate chemical and physical quality factors (which indicate end-use value) to visually-assigned grades (on which the purchaser bases his quality expectations). Consequently, Canada's grain grading system has evolved into a scientifically-based method of maximizing the amount of grain entering the higher grades, while at the same time protecting those same grades from the deleterious effects of adverse growing and harvesting conditions.

GRL scientists and technologists also support marketing programs of the Canadian Wheat Board and other grain exporters. Their visits to current or potential customer countries allow them to provide advice on processing techniques, formulation and grain type or class for optimum performance - after observing first-hand the customer's practices and needs. As well, any problems encountered by processors in using Canadian grain may be investigated and solutions recommended.

Appointments. Two new chemists joined the Laboratory's professional staff this year. **Margaret Anderson** assumed duties in the Wheat Enzymes and Asian End-products section. Her responsibilities will focus on the development of test procedures for evaluating the quality of Asian end-products, particularly noodles. **Susan Stevenson** was appointed to the Breadwheat Studies and Baking Research section where she will undertake projects in wheat protein research.

Congratulations! Keith Tipples, director of the Grain Research Laboratory, has been presented with the W.F. Geddes Award by the American Association of Cereal Chemists (AACC), an international organization of over 3000 professional members. In accepting the award, Dr. Tipples noted that Dr. Geddes, for whom the award is named, was director of the GRL from 1933 to 1938. The presentation was made at the 76th annual meeting of the AACC in Seattle, WA.

More AACC news: The Association has established an award for the best rheology paper presented by a student - and named it in honor of the late Isydore Hlynka. Dr. Hlynka was an eminent, internationally known cereal scientist who spent 25 years of his professional life at the GRL. He earned an international reputation in dough rheology, published more than 100 papers, edited the first issue of the AACC monograph entitled *Wheat: Chemistry and Technology* and was the first recipient of the Carl Wilhelm Brabender Award. In 1976, the AACC presented him with the Osborne Medal, the Association's top recognition of scientific achievement.

This year's report contains a feature section on the development and application of varietal identification technology at the Grain Research Laboratory. It was authored by Brian Marchylo and Jean Mellish and traces the history of the use of biochemical analysis in the identification of wheat and barley varieties.

The permanent staff of the GRL totalled 114 at March 31, 1992. In addition, 13 term employees and three COSEP (career-oriented summer employment program) students were employed for varying periods throughout the year.

MISSION STATEMENT AND OBJECTIVES

The mandate of the Canadian Grain Commission (CGC) is to administer the Canada Grain Act and Regulations established in 1912 and most recently amended October 17, 1988. In the interests of grain producers, and for the general advantage of Canada, the CGC's mission is *to establish and maintain standards of quality for Canadian grain* and *to regulate grain handling in Canada*, to ensure a dependable commodity for domestic and export markets. In the pursuit of its mandate and mission the CGC has set four strategic objectives:

1) to enhance the marketablilty of Canadian grain,
2) to facilitate a viable and efficient grain handling system,
3) to enhance the integrity of grain transactions and
4) to operate the CGC in an efficient and effective manner.

The mission of the Grain Research Laboratory is:

To provide scientific support for the quality assurance and market support objectives of the Canadian Grain Commission by

- **conducting research to characterize and measure end-use suitability of Canadian grain.**
- **monitoring Canadian grain for quality, safety and uniformity.**
- **providing advice, information and expertise.**

The Grain Research Laboratory provides scientific and technical support for the quality assurance and market support activities of the Commission - in pursuit of the strategic objective of enhancing the marketability of Canadian grain. About 60% of the GRL's efforts in 1991-92 were devoted to quality assurance and 40% to market support.

General commentaries on these programs and summaries of specific projects undertaken this year are provided in the sections which follow. For organizational purposes, research activities will be treated as a separate section.

QUALITY ASSURANCE ACTIVITIES

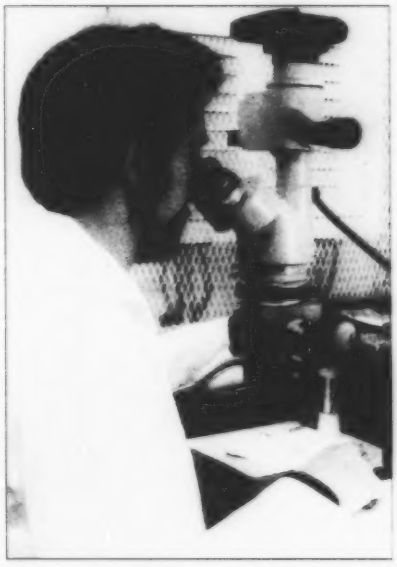
CARGO AND CARLOT MONITORING

Throughout the crop year, the Canadian Grain Commission monitors rail carlots and cargo shipments of the various classes and grades of Canadian grains and oilseeds for certain quality determinants. The major aspects of this activity are screening and monitoring to ensure freedom from toxic residues.

For the crop year ending July 31/91, a total of 1,228 cargo shipments of wheat, barley, oats, rye, canola, flax, corn, white peabean and soybean were screened for toxic substances. The analytical scope was increased this year to include glyphosate and diquat in addition to common organochlorine (OC), organophosphate (OP) and organonitrogen (ON) pesticides, phosphine, fusarium tricothecene mycotoxins, aflatoxins, ochratoxin A, zearalenone and toxic elements. Composite samples of lentils were tested for the presence of diquat, and two samples of buckwheat were screened for OC/OP/ON pesticides. The number of cargoes represented in a composite sample and the specific analyses performed were governed by the type of grain and the cargo destination.

All grain cargoes destined for the USSR, the People's Republic of China and Cuba were monitored for restricted weed seeds. These cargoes plus those of Eastern Canadian corn and soybeans and Western Canadian canola were analyzed to determine the occurrence and frequency of weed species found in Canadian exports.

Samples representing 122 cargoes (1.88 million tonnes) of canola and 36 cargoes of flax were monitored for oil and protein content, fatty acid composition, free fatty acids, glucosinolates and chlorophyll level, as applicable. A total of 137 cargoes (3.6 million tonnes) of No. 1CW feed barley were analyzed for several quality parameters, including protein and beta-glucan.



Randy Clear examines seeds for microorganisms.

TECHNICAL SERVICES

Most technical service work performed at the Grain Research Laboratory is in support of the Commission's Grain Inspection Division. The GRL maintains the accuracy of all moisture meters used at the Commission for grading and is responsible for developing new and updated moisture conversion tables for Canadian grain. There are currently 32 tables in effect for the conversion of Model 919/3.5 moisture meter readings to moisture content values.

The biweekly check test for monitoring performance of the Model 919/3.5 moisture meter was carried out for CGC and grain industry meters. Meters not functioning within specifications were recalled for servicing and electronic alignment. In addition, an on-site study of moisture content testing of Eastern Canadian corn was performed; and moisture conversion tables for use with the Model 919/3.5 moisture meter were issued this year for canola and oats.

A check sample service has been initiated by the GRL to ensure that Falling Numuer machines in regional Commission Inspection offices are giving accurate and similar results.

Commission inspectors submit carlot samples of grain they suspect may be contaminated to the GRL for toxic substance analysis. A total of 143 carlot unload samples were tested for possible admixture of treated seed. This included 75 carlots held identity preserved at terminal elevators pending results of laboratory analysis.

As required, samples of wheat and barley may also be submitted by the Commission's Grain Inspection Division for confirmation of varietal identity by chemical analysis. The catalogue of barley hordein protein fingerprints (obtained using the mini Protean II method and PhastSystem) was updated to now include 239 varieties. Research continued on the use of reversed-phase high-performance liquid chromatography in the separation of cereal proteins for potential variety fingerprinting.

Use of near-infrared transmittance (NIT) spectroscopy for whole grain moisture and protein analysis of cereals was tested thoroughly during the 1991 harvest survey. Results were good, which allowed this technique to be considered as a possible replacement for the ADA method currently in use at the Grain Inspection Division's main protein testing laboratory.

The LECO combustion nitrogen analyzer was evaluated as a potential replacement for the Grain Inspection Division's KjelFoss equipment in Vancouver and Thunder Bay. Results indicate that the LECO system merits further consideration.

Shaylene Harborne uses the Infratec 1225 Grain Analyzer to measure protein and moisture content of harvest survey samples.

GRADING FACTOR STUDIES

At the present time, the grade tolerances for tombstone kernels in wheat provide the only means of controlling maximum potential levels of deoxynivalenol (DON or vomitoxin) in cargo shipments. Studies were conducted in 1991 to further explore the relationship between measured levels of DON and percent tombstone kernels for various classes of wheat. It was concluded that the present grade tolerances for tombstone kernels are adequate to ensure that DON levels in food grade wheat cargoes are within acceptable levels.

CULTIVAR EVALUATION

Strict varietal control allows Canada to maintain superior grain quality. Before registration as a variety is possible, a new cultivar must undergo years of testing for agronomic performance, disease resistance and end-use quality. The Grain Research Laboratory contributes a large measure of expertise to the quality evaluation procedures, and has nine scientists on evaluation teams of the Prairie Registration Recommending Committee for Grain.

When plant breeders' advanced lines of malting barley are entered in the Western Cooperative Two-rowed and Six-rowed Barley Tests, it becomes the sole responsibility of the Grain Research Laboratory (GRL) to ensure that all selections are malted properly and that appropriate tests and ratings are applied for the survival and possible registration of only the most promising selections. Successful cultivars at this stage may then enter collaborative pilot-scale malting and brewing trials carried out jointly by the GRL, the Brewing and Malting Barley Research Institute and commercial maltsters and brewers.

MARKET SUPPORT ACTIVITIES

HARVEST AND CARGO SURVEYS

Surveys of the average quality of different grades of the various classes of Canadian grains and oilseeds harvested each growing season continue to be a major endeavor of the GRL. All surveys were successfully completed in time to present reports at meetings of the Eastern and Western Grain Standards Committees of the Canadian Grain Commission, at meetings held between grain industry groups and associations in Eastern Canada and the Canadian Grain Commission and at meetings and discussions held during market support visits to Japan and the United Kingdom in early November.

Crop bulletins providing detailed results of quality tests from this year's survey were published and distributed internationally for Western Canadian wheat, feed barley, malting barley, canola and flaxseed and for Ontario soybean and soft white winter wheat. These publications allow for meaningful dialogue with current and potential customers of Canadian grain on topics relating to the quality parameters normally associated with these grains and oilseeds.

Quality testing of cargo composite samples remains a high priority and cargo bulletins documenting the high quality of Canadian grain exports were published and distributed to interested parties throughout the world for *Red Spring Wheat* (Quarterly), *Amber Durum Wheat* (semi-annually) and *canola and flaxseed* (annually).

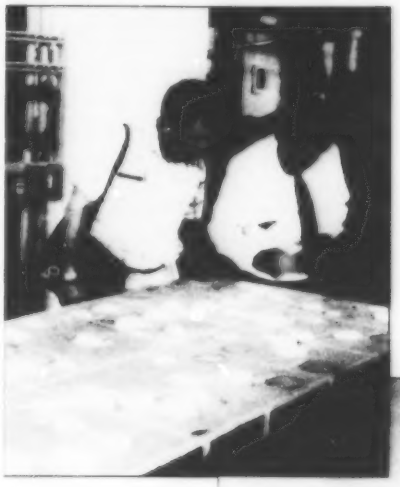
A *semi-annual analysis* of composite samples of the following wheat classes was also continued: Canada Western Red Winter, Canada Prairie Spring, Canada Western Soft White Spring, Canada Western Utility and Canada Eastern White Winter. In addition, a *monthly analysis* of canola and flax cargo composites and an *annual analysis* of feed barley cargo composites were completed.

TECHNICAL CONSULTATIONS, MISSIONS AND STUDIES

The Canadian Grain Commission cooperates with organizations such as the Canadian Wheat Board (CWB) and the Canola Council of Canada in carrying out market development and support programs. The Grain Research Laboratory director, scientists and technologists are very active in this regard in several ways. Visits to established or potential market areas are often vital and usually require describing to customers the quality and uses of Canadian grains, studying their processing techniques on-location and discussing current quality testing procedures. It may also involve investigating any problems encountered by an overseas processor in using Canadian grain. Lectures and laboratory demonstrations are provided to participants in Canadian International Grains Institute (CIGI) programs on grain handling, marketing and technology. Technical and purchasing missions visiting Canada from other countries must be provided with expert advice on end-use processing of various Canadian grains and other scientific matters including quality assurance of Canadian grain for toxic substances.

The Director visited Japan and England in November for discussions with government and industry representatives on the quality of the 1991 Canadian wheat, feed barley and canola crops. Jim Kruger and Ken Preston participated in a CWB market development initiative in Thailand, Malaysia and Singapore. Dr. Preston delivered seminars sponsored by CWB/CIGI in Brazil, Chile, Korea (with Garth Paulley) and Japan. Jim Dexter also journeyed to South America. As a follow-up to the CIGI Colombian millers program in Winnipeg, he visited flour mills, bakeries and pasta plants in Cali, Dagua, Bogota, Barranquilla, Santa Marta and Cartagena. At the request of the CWB, a presentation was made at the Latin-American seminar in Caracas, Venezuela - as well as visits to Gramovan flour mill, Cargill Co. and Monaca. Bob Matsuo provided lectures and laboratory demonstrations for CIGI course participants from Brazilian and Colombian mills - including analysis and taste tests of

spaghetti made at the GRL from Canadian durum wheat. He later sent a sample of durum to Brazil so millers could test it using their equipment and procedures. Dr. Matsuo also went to Jakarta to visit a new pasta-making plant, as well as to Algiers for a CIGI Algeria-Canada wheat symposium. Michael Edney travelled to Mexico to give seminars at a CIGI feed grains symposium. As part of a CIGI program, Jim Kruger provided an instructional program at the GRL for two visitors from the Nongshim Noodle Company, Korea. Tom Nowicki provided technical expertise to pesticide safety study teams from the Japan Scientific Feeds Association and the Japanese Food Agency on visits to terminal, primary and process elevators, on visits to farms and in meetings with various groups and government agencies.



Jim Dexter (left) examines mill streams in Colombian mill.

Ken Preston (second from left) consults with officials of a Japanese bakery.

RESEARCH ACTIVITIES

WHEAT

Evaluation of fluorescence imaging as a flour refinement predictor continued, with emphasis on improving the speed and precision of the imaging procedure and determining the effects of wheat class, environment and milling procedure on the effectiveness of the test.

Experiments on the 25 cm GRL research mill included an initial experiment in which wheat samples were conditioned to a wide range of moisture content. In succeeding experiments, middlings (farina) samples were equilibrated to various moisture content levels and ground with smooth frosted reduction rolls at several differentials to establish the effects of middling moisture content at various ratios of compression to shear on reduction grinding results.

The firmness of extruded pasta as measured by the Instron Universal Testing Machine (AACC recommended procedure) was compared with the storage modulus (G') and dynamic viscosity (n') values obtained by dynamic rheometry. A strong correlation (r^2 of at least 0.87) was found between the Instron and rheometer measurements, verifying the sensitivity of dynamic rheometry to differences in pasta firmness.

Recently, the use of bromate as a baking improver has come under attack in many countries. Individual millstreams and divide flours from a pilot milling of No.1 CWRS wheat were baked using the Canadian short process with various levels of bromate to determine oxidation requirements. The prime quality reduction streams exhibited very little response, whereas tail-end reduction streams and break flours exhibited a large bromate response.

A sensitive micro-assay for determining alpha-amylase has been developed using a kinetic microplate reader. The method has the potential to replace the current nephelometric alpha-amylase method being used at the GRL, with a consequent saving of labor and reagent costs.

Because of its known importance to noodle quality, the pasting property of starches isolated from various Canadian wheat flours has been determined with the Rapid Visco Analyzer and the Brabender Visco-Amylograph. Using the latter instrument, substantial differences between wheat classes were observed.

Methods have been implemented, using the Instron Model 4201, for measuring the breaking strength of dried noodles and the firmness, chewiness and surface firmness of cooked noodles. The Instron was interfaced with a microcomputer, greatly facilitating data capture and analysis. Texture and color are extremely important noodle quality parameters, and the GRL is now able to satisfactorily measure these attributes. This system will be able to form part of a monitoring program for noodle quality, and will enable the relative merits of various Canadian wheat classes for noodle-making to be assessed.

Experiments into using image analysis technology for determining speck count in semolina have been initiated. The possibility of quantitatively determining specks in a sheeted dough is also being examined.

Results of studies into the effects of oxidants on the bread quality, sheeting properties and oven rise of CWRS wheat flour indicate iodate, azodicarbonamide (ADA), ascorbic acid and bromate were equally effective in improving bread quality when added at optimum concentrations in the sponge-and-dough and Canadian short process methods. Cystine was equally effective in the sponge-and-dough process, but was less effective in the Canadian short process.

Based on emission maxima and quenching experiments of the fluorescence properties of gluten proteins extracted with various solvents, as well as their gel filtration fractions, it appears that tryptophan residues reside on or near the surface of these proteins in an aqueous environment. This property may allow tryptophan to be used as an intrinsic fluorescent marker in determining gluten protein interactions.

Since heat-damaged wheat proteins lack the ability to form fibrils, a method to determine possible heat damage has been developed which involves the microscopic examination of the extent of protein fibril formation in wetted flour and ground wheat. The method is very rapid and can be easily performed at grain elevators.

Garth Paulley removes flat-bread (Kobz) loaves from the oven.

The development of a procedure similar to that used by ICARDA in Syria for determining flat bread quality was completed. Under optimum conditions, CWRW, CPS-W and CPS-R wheat, milled to straight grade flour, gave best baking results.

A standard for the identification of wheat varieties by one-dimensional electrophoresis has been accepted by the International Organization for Standardization group TC34/SC4 - Cereals and Pulses. The accepted procedure is essentially the one used at the GRL for wheat variety identification.

A new type of stable, sterically protected monofunctional silane bonded phase column (C8) was evaluated and used in the reversed-phase high-performance liquid chromatographic (RP-HPLC) separation of cereal proteins for varietal identification and quality studies. This column provided superior resolution, reproducibility and stability compared with conventional columns. Also, column-to-column variability was minimal. These characteristics significantly enhance the usefulness of RP-HPLC for fingerprinting varieties and determining the relationships between proteins and quality.

BARLEY AND FEED GRAINS

Biochemical and microscopy techniques were used to study the development of hydrolytic enzymes and changes in endosperm structure during early stages of germination in a number of barley cultivars. Degradation of some barley components, especially beta-glucan, was detected within 9 to 12 hours of the barley kernels being placed on moist filter paper. This degradation confirms that the barley scutellum is a source of hydrolytic enzymes during early stages of barley germination. The results also provide new insights into the initiation and pattern of endosperm modification during malting.

The mechanism of starch degradation by alpha-amylases was explored by several different approaches. Chemical modification of the enzyme showed that the amino acid histidine plays an important role in the functionality of cereal alpha-amylases. Analysis of the action of malt alpha-amylases on malto-dextrins showed that there were subtle but significant differences in the way in which the two major alpha-amylases in malt degrade starch.

A method was developed to determine the specific activity of malt alpha-amylases. This novel method allows the relative efficiencies of cereal alpha-amylases to be measured for the first time. For example, per unit of protein, the major alpha-amylase component of malt is twice as efficient as the minor component in hydrolyzing starch.

Using a method developed for the isolation and purification of barley starch, various functional properties of normal, high amylose and waxy starches from barley were measured. The development of a practical method for purifying the different types of barley starch provides an opportunity to determine the potential value of these starches for uses such as malting, alcohol production, baking, production of biodegradable plastics and animal feeding.

Investigation of the nutritional quality of Condor barley, a hull-less variety, revealed that it had significantly higher levels of lysine, the first limiting amino acid in most grain-based animal feeds. The availability of the lysine will be studied in a collaborative project with the University of Saskatchewan and the Canadian Wheat Board.

OILSEEDS

The chlorophyll components in canola meal and oil were determined at different stages in the crushing process. During extraction, chlorophyll was shown to be changed to pheophytin, which was then changed to pyropheophytin during degumming. Meal contained only small amounts of chlorophyll residues. Methylpheophorbide *a* was identified for the first time as a chlorophyll-related component.

Frost damage was shown to increase chlorophyll levels in canola seeds, but no major changes in the types of pigments were detected.

Dolichol was found to be more concentrated in the hull than in the meat of canola seeds. The difference was not sufficient to indicate the hull as a potential source of this compound which may have pharmaceutical uses. The n-7 isomer of oleic acid was found to be present in high concentrations in triacylglycerols isolated from canola seed coats. The proportions of this isomer were also found to increase during seed maturation.

Xiaojun Hu, graduate student at the University of Manitoba, uses a gas chromatograph to determine wax components of canola seed.

ANALYTICAL METHODS

Research has commenced on the application of limited wavelength range near-infrared (NIR) spectroscopy to the large-scale whole grain analysis of cereals and oilseeds. Calibrations have been developed for the protein and moisture analysis of all types of wheat handled at the Grain Research Laboratory, as well as for barley, oats, canola, flax and soybean. Where applicable, calibrations for oil, chlorophyll and kernel texture have also been developed.

A method employing HPLC was developed for the detection of ochratoxin A and zearalenone. This resulted in a dramatic improvement in detection limits for these two mycotoxins. The procedure was then modified to allow simultaneous analysis of aflatoxins. An HPLC method has also been developed for the determination of six major alkaloids associated with ergot bodies in cereals.

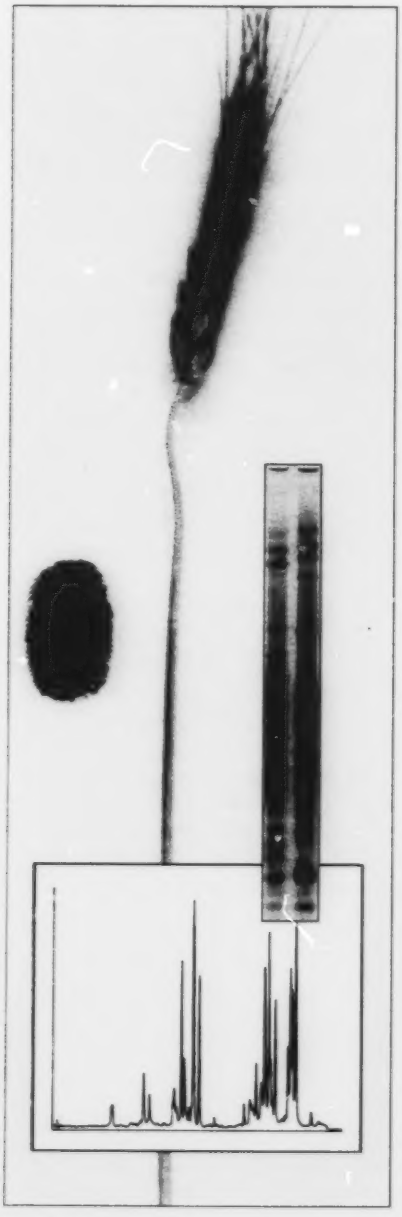
Development of new and improved gas chromatography (GC) methods for toxic substances in grain continues to be a high priority. A GC-mass selective detection (MSD) procedure has been introduced for the analysis of phenoxy acid herbicides in wheat. Development of a GC-MSD method for organic acids used in the preservation of high moisture grain is continuing.

A study of a combustion method for determination of nitrogen (protein) in canola has shown it to have greater accuracy and only slightly inferior precision than the Kjeldahl test.

High performance liquid chromatography of ethanol extracts was shown to be a possible method for identifying canola cultivars - normally not distinguishable by visual means.

THE DEVELOPMENT AND APPLICATION OF VARIETAL IDENTIFICATION TECHNOLOGY AT THE GRAIN RESEARCH LABORATORY

B.A. Marchylo & V.J. Mellish



Visual varietal identification is a key component of the grain grading system in Western Canada. Statutory specifications for the top grades of wheat and barley include varietal standards which establish varietal quality control under the grading system. Only varieties equal or superior in quality to varietal standards named in the grading schedules are eligible for the top grades. Thus, visual varietal identification is an essential part of the grading process so that inferior varieties which are not eligible for the top grades can be excluded. The suitability of a variety for a particular end-use or process, whether for baking bread, the production of pasta or noodles, the brewing of beer or the preparation of a host of other end-products, depends largely on the variety's inherent quality characteristics. Unfortunately, good grain appearance alone is not necessarily indicative of good intrinsic quality since quality can differ greatly from variety to variety irrespective of appearance.

Varieties eligible for grades within a class also must be distinguishable visually from varieties in other classes of grain to maintain the integrity of classes. In the case of malting barley, varieties eligible for the special select and select malting grades also should be visually identifiable, since industry selects malting barley on a varietal basis. Therefore, segregating western Canadian grain into grades on the basis of varietal identity and distinguishability of classes has proven to be an effective system for consistently providing a uniform high quality commodity for domestic and export markets.

Visual identification of wheat or barley varieties is no easy task and requires the trained and experienced eye of a grain inspector. Grain kernels are examined for a number of distinctive morphological or structural features. For example - colour, texture, size and shape of the kernel or characteristics of the germ end and brush are used to distinguish wheat varieties. Barley varieties are differentiated on the basis of features such as aleurone colour, basal markings, rachilla length, barbs on lateral veins or wrinkling on the hull. A complete description of these features is provided in the *Handbook on Varietal Identification by Kernel Characters - Barley, Wheat and Small Oilseeds* (Owen and Ainslie 1971).

The visual varietal identification system currently represents the most practical and efficient means for effectively grading grain in an operational environment and is highly regarded by grain exporters and importers alike. The system, however, is by no means perfect. Problems may be encountered as a result of natural variations in kernel characteristics. Environmental effects, due to soil types and climatic conditions during the growing season as well as during harvest, can hamper reliable identification. For example, this situation occurred with the barley

varieties Fairfield (malting) and Fergus (feed), which were difficult to distinguish when grown and harvested under certain environmental conditions. Incorrect identification of these varieties was unsatisfactory since differences in their quality characteristics ultimately could have caused processing problems concomitant with financial losses to industry.

Another problem arose with the proliferation of high-yielding semi-dwarf wheat varieties developed in the United States. These varieties are not registered in Canada and as such they are not eligible for the top wheat grades. Unfortunately, their kernel characteristics, as assessed visually, very closely resemble those of registered Canadian wheat varieties. This makes it more difficult to identify these varieties and thus determine the correct grade. More importantly, these non-registered varieties exhibit serious quality deficiencies. If such varieties find their way into export shipments, Canada's reputation for delivering uniform high quality wheat would be jeopardized.

In addition to these practical problems, there are two other factors that merit consideration when discussing visual identification and the grain grading system. Firstly, plant breeders have long insisted that the requirement to produce varieties with acceptable kernel characteristics (*ie*, to be visually distinguishable) is an impediment to the development of improved varieties - particularly higher yielding ones. Despite this limitation, plant breeders in Western Canada have been extremely successful in jointly maintaining intrinsic quality and visual kernel distinguishability. Secondly, there has been the recent registration of a 6-rowed yellow-aleuroned barley variety for malting and brewing (B1602). Until now, only blue-aleuroned 6-rowed barleys have been eligible for the top malting grade. The advent of varieties without the blue aleurone marker for malting quality will undoubtedly make barley varietal identification more difficult for grain inspectors and barley selectors alike.

Because of problems and considerations such as these, research into the development of alternative, non-visual biochemical variety identification techniques has been undertaken at the Grain Research Laboratory (GRL). At the GRL, it was felt that the development of this methodology would at the very least be useful as a supplement for visual identification by grain inspectors. Biochemical methods, unlike the visual method, identify varieties according to what is found inside the kernel. In particular, most methods developed to date identify varieties according to their characteristic protein composition. A wheat or barley kernel, for example, contains many types of proteins. Of these proteins, the storage proteins, and in some cases certain enzymes, are suitable for identification purposes because their composition is genetically coded and therefore can be used for varietal "fingerprinting".

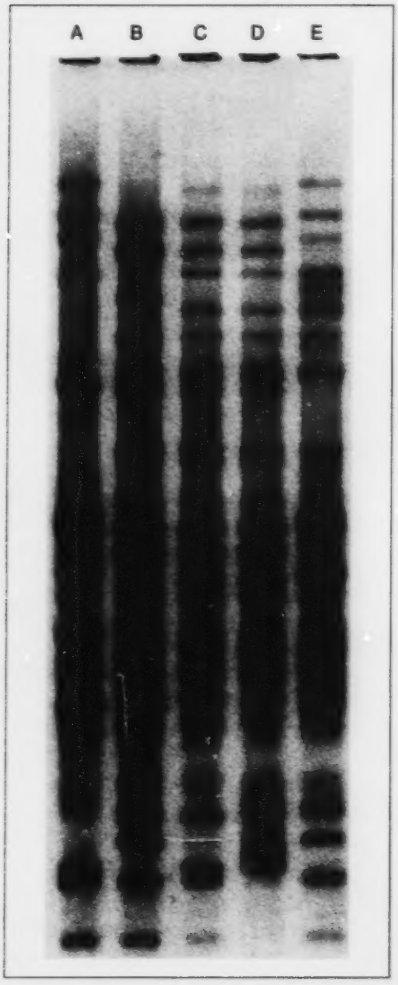
Varieties present in a sample are "fingerprinted" using the biochemical method. The protein fingerprints thus obtained are then compared with fingerprints of catalogued, known varieties to obtain a match - in much the same way as people can be identified by their fingerprints. These procedures do not rely on visual appearance of the grain and are largely unaffected by environmental conditions. There are a number of biochemical methods available which can provide protein fingerprints and at the GRL research has been performed on several of these to determine their usefulness for varietal identification. Some are now being used routinely to assist the Canadian Grain Commission's Grain Inspection Division, primarily for identification of wheat and barley varieties. A general description of the principles and development and application of this technology at the GRL follows.

In 1976, investigations into the use of electrophoresis, in particular acidic polyacrylamide gel electrophoresis (PAGE), for wheat varietal identification purposes were initiated at the GRL. In this technique, the alcohol-soluble storage proteins, the gliadins, are separated primarily according to their electrical charge - which results in a series of bands being produced in a slab of gel. This is known as an electrophoregram, the varietal fingerprint. These fingerprints differ characteristically in the number, positions and intensities of their bands, but essentially are not influenced by environment. Therefore, the fingerprint for a variety is the same regardless of where the variety is grown in the prairie provinces.

Optimum conditions for sample preparation, electrophoresis and gel staining were established (Tkachuk and Mellish 1980; Marchylo and Mellish, in press) and a reference catalogue of varietal fingerprints was compiled. For this catalogue, each variety was extensively analyzed for biotypes. Varieties such as Laura and Biggar have biotypes and are characterized by more than one fingerprint. Our current catalogue consists of 778 protein fingerprints, representing 382 registered and historical Canadian and international wheat varieties. All non-registered varieties encountered thus far can be differentiated from registered varieties by acidic PAGE; however, some registered varieties cannot be distinguished from one another due to similarity in their genetic background.

Acidic polyacrylamide gel electrophoresis is now used routinely to corroborate visual wheat varietal identification for the Grain Inspection Division, to monitor the varietal composition of samples of wheat cargoes exported from Atlantic and Pacific ports and to provide varietal data for studies at the GRL and other government departments. Electrophoretic identification is based on analysis of individual kernels. The number of kernels analyzed can range from 15 to several hundred, depending on the level of accuracy required and whether the sample is an admixture of varieties. Therefore, determination of sample identity or composition can take from one to several days.

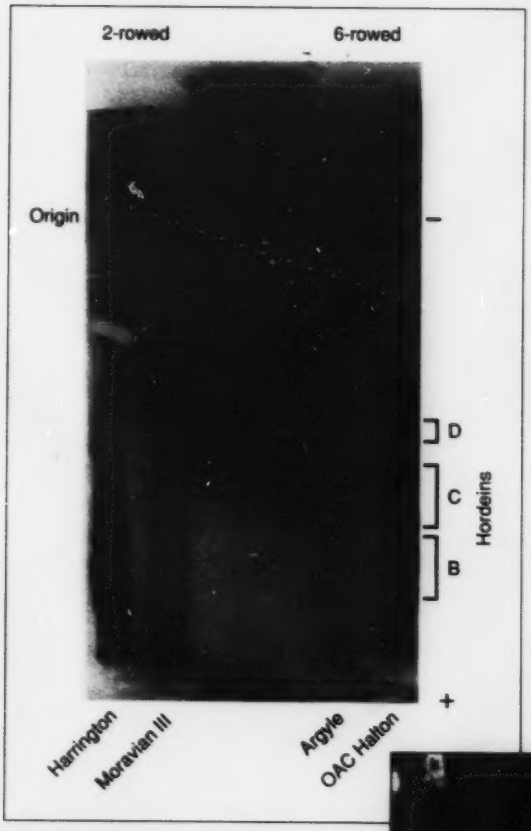
A program to develop biochemical procedures for the identification of barley varieties was also instituted in the late 1970s. As with wheat, the first technique evaluated was acidic PAGE. Hordein protein fingerprints obtained



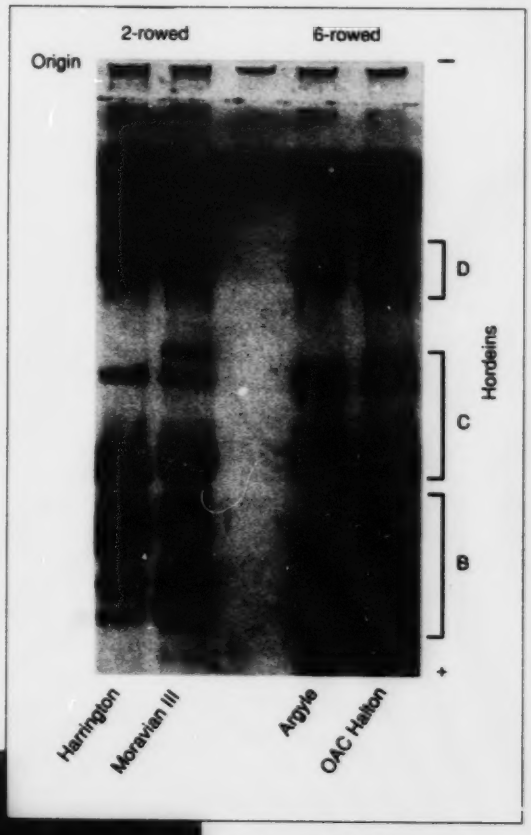
Electrophoregrams, or varietal fingerprints, of some wheat varieties:
(A) Norstar
(B) Roblin
(C) Laura biotype 1
(D) Laura biotype 2
(E) Columbus

Gerry Bell performs acidic polyacrylamide gel electrophoresis for wheat varietal identification.

by this electrophoresis procedure were qualitatively independent of environmental conditions and could be used to identify barley varieties (Marchylo and LaBerge 1980). A catalogue of protein fingerprints for 68 barley varieties was prepared (Marchylo and LaBerge 1981). It was found that although the majority of malting and feed barley varieties were distinguishable, a significant number of varieties had identical protein fingerprints and were therefore indistinguishable. In other words, some protein fingerprints were characteristic of more than one variety. This undoubtedly resulted from the similarity in genetic background of many Canadian varieties. Despite this limitation, acidic PAGE was used for a number of years as a supplementary procedure for varietal identification of barley samples on behalf of the Grain Inspection Division. Samples were analyzed on a single kernel basis and the time required per analysis was about 1 day.



Barley protein fingerprints obtained by conventional gradient sodium dodecyl sulfate polyacrylamide gel electrophoresis.



The same barley proteins resolved on miniature gels with the PhastSystem.

Garth Steidl prepares the PhastSystem for barley varietal analysis.

Because of the limitations of acidic PAGE, research was continued to evaluate another electrophoretic method with the potential to be more discriminating. This method, which is called gradient sodium dodecyl sulfate (SDS) PAGE, also produces a hordein protein fingerprint, but by a slightly different process. In this case, the proteins are separated into individual protein bands on the basis of their molecular size. In barley, these bands can be categorized broadly into three groups including the D, C and B hordeins (as shown on page 15). As with acidic PAGE, the basic analysis procedure is the same, with varietal composition being determined on a kernel-by-kernel basis in about one day. Using this procedure, a catalogue of fingerprints was prepared for over 100 Canadian barley varieties (Marchylo 1987a). As with wheat, it was discovered that many varieties were characterized by more than one protein fingerprint (*ie*, they had biotypes). Unfortunately, considerable duplication of protein fingerprints among varieties also was encountered with gradient SDS PAGE which limited it to a supplementary or confirmatory role.

Another shortcoming of conventional electrophoretic procedures is the relatively long analysis time of about one day. In an effort to improve this, a commercially available electrophoretic system called the PhastSystem was evaluated. This system uses pre-made gradient SDS PAGE materials, and the electrophoretic process itself is microprocessor controlled to give reproducible protein fingerprints. It is easy to use, safer (due to less handling of hazardous chemicals) and protein fingerprints can be obtained within half a day. Miniature electrophoretic gels (50 x 43 x 0.45 mm) are used with this system but resolution of protein bands (see page 15) is almost equal to that of the conventional systems (Marchylo and Mellish, in press).

The catalogue of protein fingerprints has been updated recently, for both conventional and PhastSystem gradient SDS PAGE, to include the fingerprints for 239 registered and historical Canadian and international barley varieties. Currently, gradient SDS PAGE is used to supplement barley varietal identification for the Grain Inspection Division, as well as occasionally to perform analyses for producers, plant breeders, industry and other government departments.

It should be noted that both conventional and PhastSystem gradient SDS PAGE procedures have been applied to the identification of wheat varieties as well (Marchylo 1987b; Marchylo and Mellish 1988; Marchylo *et al* 1989). These permit the separation of additional wheat storage proteins called glutenins and can be used to facilitate differentiation of a number of very similar varieties which are difficult to distinguish by acidic PAGE.

Since the usefulness of acidic or SDS PAGE in a routine varietal identification program is limited by the need for kernel-by-kernel analysis, the search has continued for a method which would allow composition to be determined by single analysis of ground wholemeal. Two-dimensional (2-D) electrophoresis, which combines gel isoelectric focusing and SDS-PAGE, was evaluated for this purpose. Although this technique provided powerful resolution capabilities (Tkachuk and Mellish 1987), the complexity of the technique and the necessity for elaborate computer hardware and software for gel analysis made it unsuitable for routine use.

Reversed-phase high-performance liquid chromatography (RP-HPLC) is another protein-based technique that has been applied to the identification of both barley and wheat varieties. The technology behind this procedure is quite different from that used for electrophoresis in that proteins (hordeins or gliadins and glutenins) are separated on the basis of a property called surface hydrophobicity. The end result is similar to electrophoresis in that characteristic protein fingerprints are obtained for each variety - in this case in the form of chromatograms composed of protein peaks instead of bands. This method is highly computerized and automated, and is more technologically complex than electrophoresis. It has the advantage, however, of being able to quantify the proteins more readily. This added dimension potentially could help to distinguish closely related varieties with very similar protein fingerprints.

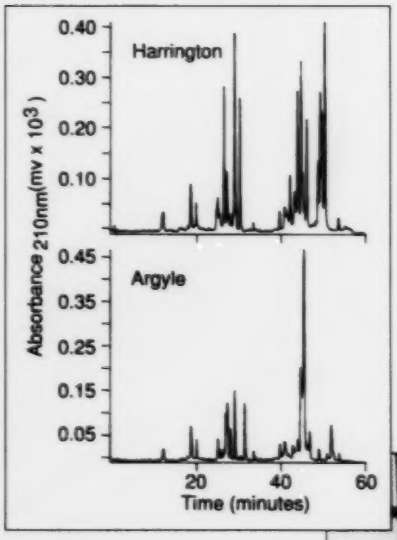
Initial work on this procedure was aimed at evaluating it for the identification of barley varieties. Results were encouraging - the cultivars Fairfield and Fergus, which were difficult to distinguish visually or by electrophoresis, were able to be distinguished by quantitative differences in their protein fingerprints (Marchylo and Kruger 1984). Further work also showed that this method could resolve more protein components which provided better discriminatory power than one dimensional electrophoresis (Marchylo and Kruger 1985). Currently, RP-HPLC is not used for the routine identification of barley samples since it remains more cost effective and efficient to perform the analysis by gradient SDS PAGE.

Identification of wheat cultivars by RP-HPLC was then tried (Marchylo *et al* 1988). As noted earlier, electrophoretic varietal identification is a relatively slow process since it is necessary to analyze a sample on a

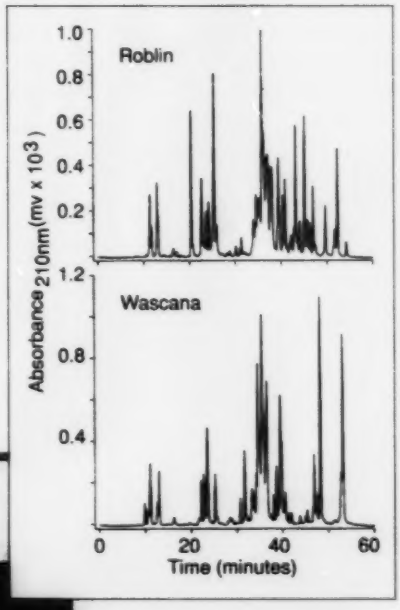
kernel-by-kernel basis. In order to achieve a good statistical determination of the proportion of varieties in a sample, it also is necessary to analyze at least 100 single kernels per sample. Evaluation of RP-HPLC was initiated to determine whether the quantitative capabilities of this technology could be used to develop a more rapid varietal identification procedure.

Preliminary work with RP-HPLC suggested that potentially it could be used to determine the varietal composition of a sample based upon single analysis of a bulk sample. If successful, significant savings in time would be realized. An in-depth assessment of RP-HPLC showed, however, that various technical hurdles limited its application to the identification of varieties on a single kernel basis (Marchylo *et al* 1988). For example, it was discovered that environmental conditions had a small but statistically significant influence on the quantitative analysis of the protein fingerprint (Marchylo *et al* 1990). It was determined that this could contribute to relatively large experimental errors in an automated varietal identification procedure, which would be unacceptable within Canada's grading system. For reasons such as these, acidic PAGE currently remains the procedure of choice for routine wheat varietal identification.

Species other than wheat and barley are now being identified or differentiated biochemically at the GRL. Various SDS-PAGE techniques have been developed to identify and discriminate lentil-like vetch seeds in commercial samples of French dark speckled lentils (Cooke and Marchylo, 1992) and to differentiate between wild sunflower species, *Helianthus annuus* and *Helianthus petiolaris* (Cooke and Mellish, unpublished). Again, these methods serve as adjuncts to conventional visual identification and grading procedures.



Chromatograms, the protein fingerprints obtained by reversed phase-high performance liquid chromatography.



Michael Nightingale loads wheat and barley samples for varietal identification by reversed phase-high performance liquid chromatography.

Application of biochemical techniques to the identification of varieties is now well-established and the potential exists for increased reliance on this kind of technology. Demand may expand to include other crops and grains such as oilseeds, oats, lentils, sunflower, etc. Future success in the development of new varieties by genetic engineering may further complicate the visual identification process and increase the requirement for biochemical techniques. Similarly, the recent registration of a yellow-aleuroned 6-rowed malting barley might eventually increase the demand for more biochemical identification of barley varieties. Finally, although it is now difficult to determine how this might impact on grain grading, the introduction of plant variety protection legislation may involve the use of biochemical variety identification procedures. It is conceivable that these procedures may become applicable to distinctness testing within the system of the International Union for the Protection of New Varieties of Plants (UPOV).

Currently, electrophoretic procedures designed to provide protein fingerprints remain the methods of choice for routine varietal identification in a support role for the Grain Inspection Division. Unfortunately, these methods suffer the inadequacies of being relatively slow and impractical in an operational environment and, in the case of barley varieties in particular, of lacking sufficient discriminatory power. Although electrophoretic technology may be refined or further improved, the problem of inadequate discrimination among closely related or similar varieties undoubtedly will remain a problem area and these procedures may not be capable of meeting future demands for varietal identification.

Thus, it would appear reasonable to assume that a new type of methodology or technology, which identifies varieties based upon a different constituent in the grain, will be needed in the future. Perhaps a completely different approach will be the solution. Ideally the method developed should be one which can determine the varietal distribution in a sample rapidly, reliably, accurately and cost effectively - the less technologically complex the system the better. Unfortunately, there does not appear to be a "black box" type of method on the horizon.

Image analysis, although technically not a biochemical procedure, initially appeared to have potential as a varietal identification procedure. Environmental influence on kernel characteristics, however, appears to have limited its usefulness for this application (Symons and Fulcher 1988). A potentially simple varietal identification procedure, based on monoclonal antibodies, has been studied in other laboratories (Dawood *et al* 1989). Various factors appear to have limited the usefulness of this method as well. Recent reports in the literature suggest that the next generation of varietal identification procedures probably will be based on DNA fingerprinting technology. In the past few years, rapid technological developments for the analysis of DNA have made this type of methodology practical. It also may offer superior discriminating power. This would be an obvious benefit in the identification of barley varieties, for example.

Whether these DNA-based procedures will meet the requirements of an operational varietal identification system is still unclear. What new biochemical techniques will be developed by continuing research efforts in this area? Only time will tell.

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LIAISON ACTIVITIES

VISITORS AND VISITS

This year, 579 people visited the Grain Research Laboratory (GRL) - with tours ranging from short walk-throughs to lengthy, detailed technical demonstrations and discussions with GRL scientists and technologists. Of the total, 83 visitors were from the following 19 countries: Algeria, Argentina, Australia, Brazil, Chile, England, France, Greece, Italy, Japan, Korea, New Zealand, Norway, People's Republic of China, Rumania, Scotland, Sweden, Turkey, Uruguay, USA. Not included in the foregoing list are countries represented by participants in Canadian International Grains Institute courses which incorporate tours of the GRL. Visitors included: 165 grain producers, 75 grain elevator managers, 25 grain marketing people, 70 agricultural organization representatives, 65 students in degree or diploma courses in agriculture at universities or community colleges and 5 persons involved with grain transportation.

Michael Sissons, holder of a visiting fellowship from the Natural Sciences and Engineering Research Council of Canada, began his term at the GRL this year. Dr. Sissons is from Adelaide, Australia and will be working with Sandy MacGregor in the Basic Barley Research section. He will be studying the role of malt alpha-glucosidase in starch granule hydrolysis. **Yasushi Endo** completed his term as post-doctoral fellow and returned home to Japan.

Visiting scientist **Yugi Yamada** completed his collaborative breadmaking studies with Ken Preston and returned to his position with the Yamazaki Baking Company in Japan. **Xiaojun Hu**, **Rod Mailer** and **Kerry Ward**, three graduate students from the University of Manitoba, continued research projects under adjunct professor Jim Daun of the GRL. Graduate students **Michelle Fleury** and **Lisa Nemeth**, also from the University of Manitoba, began research projects under the direction of adjunct professors Michael Edney and Phil Williams, respectively. **Michael Sumner**, on sabbatical leave from the University of Manitoba's Botany Department, spent several months in the GRL's microscopy section.

Russell Tkachuk was invited to visit Heilongjiang Academy of Agricultural Science, Harbin, People's Republic of China where he lectured on Canadian wheat quality and other cereal chemistry topics.

Members of the Oilseed section were involved in hosting several major meetings during 1991: ISO/TC 34/SC 2 (Oleaginous Seeds and Fruits) held July 3-5, 1991 in Winnipeg; International Rapeseed Congress held in Saskatoon July 9-11, 1991; Annual Meeting of the Canadian Section of the American Oil Chemists' Society (CAOCS) held in Winnipeg October 18 and 19, 1991 and the Annual Meeting of the Expert Committee on Fats, Oils and Other Lipids held in Winnipeg Oct. 20, 1991. Members of the section presented papers and posters at the CAOCS meeting and at the International Rapeseed Congress.

Staff members continued to maintain contact with the various elements of the Canadian grain industry by participating in informational meetings, seminars or agricultural trade shows and fairs. Among those involved this year were: Louise Cooke and Don LaBerge (industry and government grain inspector sessions), Ken Preston (producer/plant breeder/Canadian Wheat Board consultations), Bob Wallis and Josie Kopilas (Canadian Grain Commission travelling display) and Keith Tipples (Eastern Canadian grain industry association meetings). Valuable exchanges of ideas were realized through these dialogues.

COMMITTEE MEMBERSHIP

Canadian Grain Commission
- Eastern and Western Grain Standards Committees ..... K.H. Tipples

Agriculture Canada
- Advisory Committee on Variety Registration ..... R.R. Matsuo
- Expert Committee on Fats, Oils and Other Lipids ..... J.K. Daun (*secretary*)
- Prairie Registration Recommending Committee for Grain
  - Evaluation Team, Barley and Oats ..... D.E. LaBerge (*chairman*)
    M.J. Edney
    - Subcommittee on Oats Evaluation ..... M.J. Edney
  - Evaluation Team, Oilseeds ..... J.K. Daun (*chairman*)
  - Evaluation Team, Special Crops ..... R. Tkachuk
  - Evaluation Team, Wheat, Rye and Triticale ..... K.R. Preston (*chairman*)
    B.A. Marchylo
    R.R. Matsuo
    K.H. Tipples
    P.C. Williams
- Western Canada Canola/Rapeseed Recommending Committee Inc ..... J.K. Daun
- Western Expert Committee on Grain ..... K.H. Tipples

Agricultural Institute of Canada
- Associate Editor, *Canadian Journal of Plant Science* ..... S.J. Symons

American Association of Cereal Chemists
- Technical Committees:
  - Amylase Methods ..... J.E. Kruger (*co-chairman*)
    A.W. MacGregor (*co-chairman*)
  - Barley and Barley Products ..... M.J. Edney
  - Bread Baking Methods ..... K.R. Preston
  - Experimental Milling ..... J.E. Dexter (*chairman*)
  - Methods for Grain Testing ..... P.C. Williams
    M.J. Edney
  - Near-infrared Reflectance ..... P.C. Williams
  - Oat Bran ..... P.C. Williams
  - Pasta Products Analysis ..... J.E. Dexter
    R.R. Matsuo
  - Physical Testing Methods ..... K.R. Preston
  - Quality Tests for Wheat and Flour ..... R. Tkachuk
  - Total Dietary Fiber ..... P.C. Williams
  - Yeast Evaluation ..... P.C. Williams
- Board of Directors ..... J.E. Kruger
- Board of Editors, *Cereal Chemistry* ..... B.A. Marchylo
- Canadian Prairie Section ..... J.E. Morgan (*secretary-treasurer*)
- Editorial Advisory Committee, *Cereal Foods World* ..... J.E. Dexter
- Emerging Issues Committee ..... K.H. Tipples
- Osborne Medal Award Committee ..... K.R. Preston (*chairman*)
- Program Advisory Committee ..... J.E. Dexter
- Publications Committee ..... J.E. Kruger
- Technical Program Committee - 1993 Annual Meeting ..... J.E. Dexter (*chairman*)

American Oil Chemists' Society
- Annual Meeting (1992) - Technical Program ..... J.K. Daun (*chairman*)
- Awards Administration ..... J.K. Daun
- Canadian Section ..... J.K. Daun (*president*)
- Seed and Meal Analysis Committee ..... J.K. Daun (*chairman*)

Association of Official Analytical Chemists International
- Mid-Canada Regional Section ..... T.W. Nowicki (*president*)

Brewing and Malting Barley Research Institute
- Technical Committee ..... D.E. LaBerge

Canadian Association of Pest Control Officials - Check Sample Program
- Feeds/Grains Sub-program ..... T.W. Nowicki (*coordinator*)

Canadian Chemical Conference and Exhibition (1994)
- General Program Committee ..... R. Tkachuk (*chairman*)

Canadian General Standards Boards
- Committee on Bakery and Cereal Products ..... R.R. Matsuo

Codex Alimentarius Commission, FAO/WHO
- Canadian Delegation ..... R. Tkachuk (*chairman*)

Eastern Prairie Barley Group ..... M.J. Edney
D.E. LaBerge

European Brewing Convention Barley and Malt Group
- Barley Quality Assessment Subgroup ..... A.W. MacGregor

Flax Council of Canada
- Market Development Committee ..... J.K. Daun
- Research and Technical Committee ..... J.K. Daun

Group consultatif international pour la research sur la colza ..... J.K. Daun

Institute of Food Technologists
- Committee on Constitution and By-Laws ..... E. Larmond

International Association for Cereal Science and Technology (ICC)
- Executive Committee and General Assembly ..... K.H. Tipples
- Working Groups on:
  - Baking ..... K.R. Preston (*co-chairman*)
  - Colorimetric Amylase Methods ..... J.E. Kruger
  - Determination of Wet Gluten ..... K.R. Preston
    P.C. Williams
  - Particle Size/Wheat Hardness ..... P.C. Williams
  - Methods of Protein Determination ..... R. Tkachuk
  - Milling J.E. Dexter
  - Sampling ..... P.C. Williams
  - Near-infrared Technology ..... P.C. Williams
  - Variety Identification by Electrophoresis ..... R. Tkachuk

International Committee on Pre-Harvest Sprouting ..... J.E. Kruger

International Rapeseed Congress (1991)
- Program Committee ..... J.K. Daun

International Organization for Standardization
- Canadian Advisory Committee TC34/SC4 ..... K.H. Tipples (*chairman*), R.Tkachuk
- Canadian Advisory Committee TC34/SC2 ..... J.K. Daun
- Canadian Advisory Committee TC34/SC11 ..... J.K. Daun

Journal of Cereal Science
- Board of Editors ..... K.H. Tipples

Journal of the Institute of Brewing
- Editorial Board ..... A.W. MacGregor

Manitoba Sunflower Committee ..... J.K. Daun

Master Brewers' Association of the Americas
- Housing Committee - District Western Canada 1992 Convention ..... D.E. LaBerge (*chairman*)

National Research Council of Canada
- Industrial Research Assistance Program (IRAP)
  - Development of Quality Malt Using Analogs of Abscisic Acid
    - Scientific Advisor ..... D.E. LaBerge

Society for Technical Communication
- Manitoba Chapter ..... P.R. March (*secretary*)

Statistical Society of Canada
- Board of Directors ..... J.C. Babb
- Public Relations ..... J.C. Babb
- Regional and Society Cooperation ..... J.C. Babb (*chairman*)

University of Guelph
- Adjunct Professor ..... P.C. Williams

University of Manitoba
- Adjunct Professors ..... J.K. Daun, J.E. Dexter, M.J. Edney, J.E. Kruger, E. Larmond, A.W. MacGregor, R.R. Matsuo, R.Tkachuk, P.C.Williams

CONFERENCE AND MEETING ATTENDANCE

Agriculture Canada

Eastern Expert Committee on Cereals and Oilseeds
Meeting in Saskatoon, SK ..... M.J. Edney

Expert Committee on Fats, Oils and Other Lipids
1991 Meeting, Winnipeg, MB ..... J.K. Daun

Western Expert Committee on Grain
1992 Meeting, Saskatoon, SK ..... K.H. Tipples

Prairie Registration Recommending Committee for Grain
1992 Meeting, Saskatoon SK ..... J.K. Daun
M.J. Edney
D.E. LaBerge
B.A. Marchylo
R.R. Matsuo
K.R. Preston
K.H. Tipples
R. Tkachuk
P.C. Williams

American Association of Cereal Chemists
Annual Meeting, Seattle, WA ..... J.E. Dexter
M.J. Edney
J.E. Kruger
R.R. Matsuo
K.H. Tipples

Board of Directors Meeting
St. Paul, MN ..... J.E. Kruger

Book Committee Meeting
St. Paul, MN ..... J.E. Kruger

Milling and Baking Division
Technical Conference, Fargo, ND ..... J.E. Dexter
E.J. Gander
E. Mydlo
K.R. Preston

American Oil Chemists' Society
Annual Conference, Chicago, IL ..... J.K. Daun
Canadian Section Meeting, Winnipeg, MB ..... K.M. Clear
J.K. Daun
D.R. DeClercq
H.K. Howard
P.B. Mazur
B.A. Misener
B.S.K. Ng
C.T. Thorsteinson

American Society of Brewing Chemists
Annual Meeting, San Antonio, TX ..... B.A. Marchylo

District Northwest/District Western Canada MBAA
Joint Meeting, Vancouver, BC ..... D.E. LaBerge

Association of Official Analytical Chemists
International Meeting, Phoenix, AZ ..... T.W. Nowicki

Association of Official Seed Analysts/Society of Commercial Seed Technologists
Joint Meeting, Lexington, KY ..... L.A. Cooke

Association of Operative Millers
Annual Conference, Kansas City, MO ..... D.G. Martin
District #8 Meeting, Saddle Brook, NJ ..... K.R. Preston

Biennial Barley Conference
Grand Forks, ND ..... D.E. LaBerge

Canadian Phytopathological Society
Regional Conference, Winnipeg, MB ..... R.M. Clear

Canola Industry Conference
Saskatoon, SK ..... D.R. DeClercq

Cereals International 91
Brisbane, Australia ..... K.R. Preston

Eastern Grain Standards Committee
1991 Meeting, Toronto, ON ..... K.H. Tipples

Eighth World Congress of Food Science and Technology
Toronto, ON ..... J.E. Kruger
R.R. Matsuo
K.H. Tipples

European Brewery Convention
1991 Congress, Lisbon, Portugal ..... A.W. MacGregor

Fumonisin Symposium
Raleigh, NC ..... R.M. Clear

Grain Elevator and Processing Society
Annual Meeting, Nashville, TN ..... T.W. Nowicki

Industrial Accident Prevention Association of Ontario
Safety Conference, Toronto, ON ..... S.A. HayGlass

International Association for Cereal Science and Technology(ICC)
Executive Committee Meeting and 1991 Congress
Prague, Czechoslovakia ..... K.H. Tipples

International Barley Genetics Symposium
Helsingborg, Sweden ..... A.W. MacGregor

International Electrophoresis Conference
London, England ..... R. Tkachuk

International Near-Infrared Symposium
Aberdeen, Scotland ..... P.C. Williams

International Rapeseed Conference
Saskatoon, SK ..... J.K. Daun
D.R. DeClercq

International Standards Association
TC34/SC2 Committee Meeting, Winnipeg, MB ..... J.K. Daun

Institute of Food Technologists
Constitution and By-Law Committee
Meeting in Chicago, IL ..... E. Larmond
Meeting in Houston, TX ..... E. Larmond

Latin-American Seminar: Trends in Pasta Production
Caracas, Venezuela ..... J.E. Dexter

Manitoba Agri-Forum
Winnipeg, MB ..... L.A. Cooke

Microscopical Society of Canada
Annual Meeting, Calgary, AB ..... S.J. Symons

National Conference on Weights and Measures
Technical Committee Meeting, Kansas City, MO ..... P.C. Williams

National Research Council of Canada
Industrial Research Assistance Program
Project Meeting, Saskatoon, SK ..... D.E. LaBerge

Natural Sciences and Engineering Research Council of Canada
Strategic Grants Committee Meeting
Ottawa, ON ..... J.K. Daun

Pesticide and Trace Organic Residue Analysts (Western Canada)
Annual Workshop, Calgary, AB ..... T.W. Nowicki
J.W. Thorsteinson

Starch Round Table
Seattle, WA ..... A.W. MacGregor

Statistical Association of Manitoba
Annual Meeting, Grand Forks, ND ..... J.C. Babb

Statistical Society of Canada
Annual Meeting, Toronto, ON ..... J.C. Babb

University of Manitoba Weed Tour
Portage la Prairie, MB ..... K.E. Bell
C.D. Butler
L.A. Cooke
B.M. Moody

Western Barley Growers Association
Annual Meeting, Kananaskis, AB ..... D.E. LaBerge

Western Canada Agribition
Regina, SK ..... R.J. Wallis

Western Grain Standards Committee
1991 Meeting, Winnipeg, MB ..... K.H. Tipples

Western Nutritional Conference
Winnipeg, MB ..... M.J. Edney

ORAL PRESENTATIONS

At Canadian International Grains Institute

K.H. Tipples
Introduction to the Grain Research Laboratory (presented twice)

R.M. Clear
Grain Mycology

L.A. Cooke
Weed Seed Monitoring at the Grain Research Laboratory

D.A. Daniel
Demonstration of Sprout Damage Measurement Techniques (presented five times)

R.W. Daniel
Practical Session on Durum Wheat Technology (presented four times)

J.K. Daun
Effects of Degrading Factors on End-use Quality of Canadian Oilseeds
Oilseed Grading Factors and Related End-use Product Quality
Introduction to the Grain Research Laboratory

D.R. DeClercq
Quality Monitoring of Canadian Oilseed Crops
Practical Session on Oilseed Technology (presented twice)

J.E. Dexter
Relation of Wheat Class and Grade to End-use Quality
Effects of Grading Factors on End-use Quality of Canadian Wheat
Laboratory Milling of Canada Prairie Spring Wheat
Quality of Canada Prairie Spring Wheat and Flour

L.G. Dushnicky
Demonstration in Microscopy Techniques (presented five times)

M.J. Edney
Feed Grain Research at the Grain Research Laboratory (presented four times)

D.W. Hatcher
Demonstration in Wheat Enzymology Methods (presented twice)

S.A. HayGlass
A Framework for an Effective Health and Safety Program

J.E. Kruger
Demonstration in Wheat Enzymology Methods (presented four times)
Tour of the Grain Research Laboratory

D.E. LaBerge
Malting Barley in Western Canada
Demonstration of Malting and Barley and Malt Analysis

J.J. Lachance and D.G. Martin
Laboratory Milling Demonstration

A.W. MacGregor
Demonstration in Barley Research Section (presented five times)

E. Larmond
Introduction to the Grain Research Laboratory (presented three times)

P.R. March, L.M. Macri and G.G. Bell
Tour of the Grain Research Laboratory

B.A. Marchylo
Demonstration of Cereal Protein Characterization Methods (presented four times)
Demonstration of Barley Variety Identification by Chemical Analysis (presented twice)

D.G. Martin
Experimental Milling Demonstration (presented four times)

R.R. Matsuo
Demonstration of Durum Wheat Quality Analysis

R.R. Matsuo and R.W. Daniel
Practical Session on Durum Wheat Technology (presented twice)

V.J. Mellish
Demonstration of Wheat Variety Identification by Electrophoresis (presented six times)

E. Mydlo
Demonstration of Baking Quality Evaluation Techniques

T.W. Nowicki
Demonstration of Residue Analysis of Grain (presented twice)

K.R. Preston and E. Mydlo
Demonstration of Baking Quality Evaluation Techniques

S.J. Symons
Demonstration of Image Analysis Techniques (presented four times)

C.T. Thorsteinson
Tour of the Grain Research Laboratory

L.C.M. Van Schepdael
Demonstration of Image Analysis Techniques

P.C. Williams
Demonstration of Analytical Methodology

P.C. Williams and D.C. Sobering
Demonstration of Grain Quality Analysis by Near-infrared Techniques (presented twice)

At Conferences, Meetings and Seminars

K.H. Tipples
Canadian Quality Assurance and Surveillance Programs for Toxic Substances in Grain
Quality Requirements for Cereal Grains Used in North American Breakfast Cereals
ICC Symposium on Cereal Based Foods, Prague, Czechoslovakia
Breadwheat Quality Defined
Eighth World Congress of Food Science and Technology, Toronto, ON

R.M. Clear
Frequency and Distribution of Seedborne Fungal Pathogens in Western Canadian Canola
AOCS, Canadian Section Meeting, Winnipeg, MB

L.A. Cooke
Seed Mycology at the Grain Research Laboratory
AOSA/SCST Joint Meeting, Lexington, KY
Seed Analyst to Grain Quality Biologist
St. James Business and Professional Women's Club Meeting, Winnipeg, MB

L.A. Cooke and D.E. LaBerge
Grain Biology for Grain Inspectors
Barley Nobody Malts
A Series of Four Seminars Presented to Canadian Grain Commission and Grain Trade Inspectors, Vancouver, BC

J.K. Daun
Potential of Low Temperature Drying for Reducing Green Seeds in Canola
International Rapeseed Conference, Saskatoon, SK

D.R. DeClercq

Quality of Western Canadian Canola 1991
Canola Industry Meeting, Saskatoon, SK

Sulfur Levels in Canola Oils from Canadian Crushing Plants: Analysis by Raney Nickel Reduction and Inductively Coupled Plasma Atomic Emission Spectroscopy
International Rapeseed Conference, Saskatoon, SK

J.E. Dexter

An Overview of Milling and Baking in South America
AACC, Annual Meeting, Seattle, WA

Removal of Damaged and Sprouted Kernels from Wheat with a Specific Gravity Table
AACC Milling and Baking Technical Conference, Fargo, ND

Quality Characteristics of Canadian Durum Wheat
Latin-American Seminar, Caracas Venezuela

L.G. Dushnicky

Application of Microscopy to Cereal Research
Dept. of Plant Sciece, University of Manitoba, Winnipeg, MB

M.J. Edney

Quality Parameters and Feed Barley Registration
PRRCG Meeting, Saskatoon, SK

Quality of Western Canadian Feed Barley
Eastern Expert Committee of Cereals and Oilseeds, Meeting in Saskatoon, SK

S.A. HayGlass

Effectively Incorporating Safety into Your Laboratory
AOCS, Canadian Section Meeting, Winnipeg, MB

Eye Conservation Policy

Accident Prevention
Grain Research Laboratory, Winnipeg, MB

J.E. Kruger

Enzymes of Sprouted Grain and Their Technological Significance
Eighth Congress of Food Science and Technology, Toronto, ON

Comparison of Methods for Prediction of Cantonese Noodle Color (Poster)
AACC, Annual Meeting, Seattle, WA

D.E. LaBerge

Comparison of Malting and Brewing Properties of Commercial Samples of Barley from the USA, France, Australia and Canada
ASBC District Northwest/MBAA District Western Canada, Joint Meeting, Vancouver, BC

Role of the Grain Research Laboratory in the Grain Industry
Westbrook Grain Marketing Group, Meeting in Winnipeg, MB

The Importance of Protein Content in the Selection of Malting Barley
Western Barley Growers Association, Annual Meeting, Kananaskis, AB

A.W. MacGregor

The Effect of Barley Structure and Composition on Malt Quality
European Brewery Convention, 1991 Congress, Lisbon, Portugal

Evaluation of Malting Barley
International Barley Genetics Symposium, Helsingborg, Sweden

B.A. Marchylo

Short Course Lecture

MBAA, Brewing and Malting Science, Madison, WI

R.R. Matsuo

Durum Wheat: Its Unique Pasta Making Properties

Eighth World Congress of Food Science and Technology, Toronto, ON

Canadian Wheat Varieties and the Varietal Selection Process

Algeria-Canada Wheat Symposium, Algiers, Algeria

New Technologies for a More Rational Transformation of Cereal Products

Symposium: Guidelines for the Development of Grain Grown in Poland, Warsaw, Poland

T.W. Nowicki

Determination of Diquat in Lentils

Pesticide and Trace Organic Residue Analysts (W. Canada), Annual Workshop, Calgary, AB

Food Safety Challenge: Grain Exporters Meeting Customer Demands

Grain Elevator and Processing Society, Annual Meeting, Nashville, TN

K.R. Preston

Quality of the 1991 Canadian Wheat Crop

AOM, District #8 Meeting, Saddle Brook, NJ

Effects of Oxidants on the Oven Rise Properties of Canadian Short Process Bread

Cereals International Conference, Brisbane, Australia

S.J. Symons

Quantitative Fluorescence Imaging: A Rapid Procedure for the Measurement of Flour

Microscopical Society of Canada, Annual Meeting, Calgary, AB

R. Tkachuk

A Series of Lectures on Cereal Chemistry

Heilongjiang Academy of Agricultural Sciences, Harbin, People's Republic of China

P.C. Williams

Comparison of Software in Prediction of Dietary Fibre Components in Oat Bran by NIRS

The Future Application of NI Spectroscopy - Prediction of Functionality and the End of Composition Analysis

International Near-Infrared Symposium, Aberdeen, Scotland

PUBLICATIONS

SCIENTIFIC PAPERS

648 MARCHYLO, B.A., KRUGER, J.E. and HATCHER, D.W.
Quantitative Analysis of HMW Glutenin Subunits by RP-HPLC
Proc. Fourth Int. Work. Glut. Prot., pp 334-348, AACC, 1991

654 PRESTON, K.R., KILBORN, R.H., MORGAN, B.C. and BABB, J.C.
Effects of Frost and Immaturity on the Quality of a Canadian Hard Red Spring Wheat
Cereal Chem. 68(2):133-138, 1991

655 MELLISH, V.J. and TKACHUK, R.
Two-Dimensional Electrophoresis of Wheat Proteins: A Comparison of Staining Procedures
Proc. Fourth Int. Work. Glut. Prot., pp 482-490, AACC, 1991

657 COOKE, L.A. and MARCHYLO, B.A.
Rapid Electrophoretic Detection of a Lentil-like Vetch (*Vicia sativa* L.) in Commercial Samples of French Dark Speckled Lentils (*Lens culinaris* Medik)
Plant Varieties and Seeds 5:1-11, 1992

658 MARCHYLO, B.A., LUKOW, O.M. and KRUGER, J.E.
Quantitative Variation in High Molecular Weight Glutenin Subunit Seven in Some Canadian Wheats
J. Cereal Science 15:29-37, 1992

660 DEXTER, J.E., TKACHUK, R. and TIPPLES, K.H.
Physical Properties and Processing Quality of Durum Wheat Fractions Recovered from a Specific Gravity Table
Cereal Chem. 68(4):401-405, 1991

661 TKACHUK, R., DEXTER, J.E. and TIPPLES, K.H.
Removal of Sprouted Kernels from Hard Red Spring Wheat with a Specific Gravity Table
Cereal Chem. 68(4):390-395, 1991

662 TKACHUK, R., DEXTER, J.E., TIPPLES, K.H. and NOWICKI, T.W.
Removal by Specific Gravity Table of Tombstone Kernels and Associated Trichothecenes from Wheat Infected with Fusarium Head Blight
Cereal Chem. 68(4):428-431, 1991

663 SYMONS, S.J. and DEXTER, J.E.
Computer Analysis of Fluorescence for the Measurement of Flour Refinement as Determined by Flour Ash Content, Flour Grade Color and Tristimulus Color Measurements
Cereal Chem. 68(5):454-460, 1991

664 MATSUO, R.R., MALCOLMSON, L.J., EDWARDS, N.M. and DEXTER, J.E.
A Colorimetric Method for Estimating Spaghetti Cooking Loss
Cereal Chem. 69(1):27-29, 1992

666 CLEAR, R.M.
Frequency and Distribution of Seedborne Fungal Pathogens in Western Canadian Canola - 1989 and 1990
Can. Plant Dis. Survey 72(1):21-28, 1992

667 SYMONS, S.J. and DEXTER, J.E.
Estimation of Milling Efficiency: Prediction of Flour Refinement by the Measurement of Pericarp Fluorescence
Cereal Chem. 69(2):137-141, 1992

669 CLEAR, R.M. and PATRICK, S.K.
A Simple Medium to Aid the Identification of *Fusarium moniliforme*, *F. proliferatum* and *F. subglutinans*
J. Food Protection 55(2):120-122, 1992

MISCELLANEOUS PAPERS

M166 KRUGER, J.E., MACGREGOR, A.W. and MARCHYLO, B.A.
Endogenous Cereal Enzymes
Food Enzymology, Vol.2, Chap.17, pp 1-46, Elsevier Applied Science, London and New York, 1991

M167 MARTIN, D.G. and DEXTER, J.E.
A Tandem Buhler Laboratory Mill: Its Development and Versatility
Bulletin of the AOM, April, 5855-5864, 1991

M173 MACGREGOR, A.W.
The Effect of Barley Structure and Composition on Malt Quality
Proc. Twenty-third Brewery Convention, pp 37-50, Oxford University Press, 1991

M177 DAUN, J.K.
Workshop: Analysis of Canola and Rapeseed in Value-added Payment Systems. I. The Situation in Canada
GCIRC Bulletin 8:102-103, 1992

PERIODICALS

Sixty-fourth Annual Report. 1990-91 Report of the Grain Research Laboratory

Cargo Bulletins

Red spring wheat editions were published in an English-French-German-Spanish version and an English-Chinese Version (suffix"C").

Amber durum wheat editions were published in an English-French-German-Italian version.

262 Quality of Canadian Grain Exports 1990-91, Red Spring Wheat, second quarter, (Nov. 1 to Jan. 31)

263 Quality of Canadian Grain Exports 1990-91, Amber Durum Wheat, first and second quarters (Aug. 1 to Jan. 31)

264 Quality of Canadian Grain Exports 1990-91, Red Spring Wheat, third quarter (Feb. 1 to Apr. 30)

265 Quality of Canadian Grain Exports 1990-91, Red Spring Wheat, fourth quarter (May 1 to July 31)

266 Quality of Canadian Grain Exports 1990-91, Amber Durum Wheat, third and fourth quarters (Feb. 1 to July 31)

267 Quality of Canadian Canola and Flaxseed Cargoes, 1990-91 Crop Year

Crop Bulletins

190 Quality of Ontario Soft White Winter Wheat 1991

191 Quality of Western Canadian Wheat 1991

192 Quality of Western Canadian Feed Barley 1991

193 Quality of Western Canadian Malting Barley 1991

194 Quality of Western Canadian Canola 1991

195 Quality of Western Canadian Flaxseed 1991

196 Quality of Canadian Soybean 1991

GRL Digest (Newsletter)

Vol.1, No.4 August 1991

Vol.2, No.1 November 1991

Vol.2, No.2 February 1992

OTHER PUBLICATIONS

Quality Evaluation Methods for Red Spring Wheat
Second Edition, Grain Research Laboratory, January 1992

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S.J. Symons

R.M. Clear

L.A. Cooke

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D.R. DeClercq

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PUBLICATIONS AND DURUM WHEAT RESEARCH

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D.W. Hatcher

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S.E. Gowan, *Dipl T*, G.G. Bell, *Dipl T*,
K. Jarrin, *Dipl T* ..... Scientific Support

[1] Separated from staff during this reporting period.
[2] Term appointment.
[3] On extended leave.
[4] On developmental assignment in another Division.

RECYCLED PAPER